CLAIMS

What is claimed is:

1. A method for designing a roller-cone earth-penetrating drill bit, comprising the actions of:

simulating the unconstrained motion of cones of a roller-cone earth-penetrating drill bit, including the trajectories of teeth thereof through rock being drilled;

and, for multiple respective ones of said teeth, both adjusting a respective crest orientation thereof, in accordance with the general direction of the trajectory of said tooth in a plane normal to the wellbore axis,

and also

adjusting an axis of said tooth in accordance with the angle at which said tooth indents said rock at the start of said trajectory of said tooth.

2. The method of Claim 1, wherein the action of simulating the unconstrained motion of cones of a roller-cone earth-penetrating drill bit includes the three-dimensional trajectories of teeth thereof through rock being drilled.

3. The method of Claim 1, wherein said bit comprises exactly three of said cones.

4. The method of Claim 1, wherein said cones have a bulged frustro-conical shape.

5. The method of Claim 1, wherein said teeth are inserts mounted on the bodies of said cones.

6. The method of Claim 1, wherein said teeth are formed integrally with the bodies of said cones.

7. The method of Claim 1, wherein each of said cones differs from the others.

8. The method of Claim 1, wherein said crests are straight.

9. The method of Claim 1, wherein said crests have a length which is between one-third and two-thirds of the width of a tooth.

10. The method of Claim 1, wherein said tooth is symmetric about an axis, and said adjusting step changes said axis.

11. The method of Claim 1, wherein said tooth has a tip portion which is symmetric about a first axis, and has a root portion which is not symmetric about said first axis, and said adjusting step changes said first axis.

12. The method of Claim 1, wherein said tooth has a tip portion which is symmetric about a first axis, and has a root portion which is symmetric about a second axis, and said adjusting step changes said first axis.

13. The method of Claim 1, wherein said crest of at least one tooth intersects said axis thereof.

14. The method of Claim 1, wherein said crest of at least one tooth does not intersect said axis thereof.

15. The method of Claim 1, wherein said crest of at least one tooth is perpendicular to said axis thereof.

16. The method of Claim 1, wherein the angle of the axis varies for the teeth on a single row.

17. A method for designing a roller-cone earth-penetrating drill bit, comprising the actions of:

fully simulating the motion of a roller-cone earth-penetrating drill bit, including the unconstrained rotation of cones thereof, and the trajectories of teeth supported by said cones through rock being drilled;

and, for multiple respective ones of said teeth, both adjusting a respective crest orientation thereof, and also adjusting an axis of said tooth in accordance with the angle at which said tooth indents said rock at the start of said trajectory of said tooth.

18. The method of Claim 17, wherein two axes of said tooth are adjusted.

19. The method of Claim 17, wherein said bit comprises exactly three of said cones.

20. The method of Claim 17, wherein said teeth are inserts mounted on the bodies of said cones.

21. The method of Claim 17, wherein said teeth are formed integrally with the bodies of said cones.

22. The method of Claim 17, wherein said crests are straight.

23. The method of Claim 17, wherein said crests have a length which is between one-third and two-thirds of the width of a tooth.

24. The method of Claim 17, wherein said tooth is symmetric about an axis, and said adjusting step changes said axis.

25. The method of Claim 17, wherein said tooth has a tip portion which is symmetric about a first axis, and has a root portion which is not symmetric about said first axis, and said adjusting step changes said first axis.

26. The method of Claim 17, wherein said crest of at least one tooth intersects said axis thereof.

27. The method of Claim 17, wherein said crest of at least one tooth does not intersect said axis thereof.

28. The method of Claim 17, wherein the angle of the axis varies for the teeth on a single row.

29. A method for designing a roller-cone earth-penetrating drill bit, comprising the actions of:

simulating the trajectories of teeth supported by cones of said drill bit through rock under drilling conditions;

and, for multiple respective ones of said teeth, adjusting at least two different orientation angles thereof,

said orientation angles being different from parameters which define the characteristics of the respective tooth, and different from parameters which define the location of the respective tooth on the surface of the cone.

30. The method of Claim 29, wherein at least three different orientation angles are adjusted.

31. The method of Claim 29, wherein said bit comprises exactly three of said cones.

32. The method of Claim 29, wherein said teeth are inserts mounted on the bodies of said cones.

33. The method of Claim 29, wherein said teeth are formed integrally with the bodies of said cones.

34. The method of Claim 29, wherein said crests are straight.

35. The method of Claim 29, wherein said crests have a length which is between one-third and two-thirds of the width of a tooth.

36. The method of Claim 29, wherein said tooth is symmetric about an axis, and said adjusting step changes said axis.

37. The method of Claim 29, wherein said tooth has a tip portion which is symmetric about a first axis, and has a root portion which is not symmetric about said first axis, and said adjusting step changes said first axis.

38. The method of Claim 29, wherein said crest of at least one tooth intersects said axis thereof.

39. The method of Claim 29, wherein said crest of at least one tooth does not intersect said axis thereof.

40. The method of Claim 29, wherein the angle of the axis varies for the teeth on a single row.

41. A method for designing a roller-cone earth-penetrating drill bit, comprising the actions of:

simulating the unconstrained motion of cones of a roller-cone earth-penetrating drill bit, including the three-dimensional trajectories of teeth thereof through rock being drilled;

and, for at least one of said teeth, adjusting an axis of said tooth in accordance with the direction at which said tooth indents said rock at the start of said trajectory.

42. The method of Claim 41, wherein said axis of said tooth is adjusted in accordance with the three-dimensional vector at which said tooth indents said rock at the start of said trajectory.

43. The method of Claim 41, wherein said bit comprises exactly three of said cones.

44. The method of Claim 41, wherein said teeth are inserts mounted on the bodies of said cones.

45. The method of Claim 41, wherein said teeth are formed integrally with the bodies of said cones.

46. The method of Claim 41, wherein said crests are straight.

47. The method of Claim 41, wherein said crests have a length which is between one-third and two-thirds of the width of a tooth.

48. The method of Claim 41, wherein said tooth is symmetric about an axis, and said adjusting step changes said axis.

49. The method of Claim 41, wherein said tooth has a tip portion which is symmetric about a first axis, and has a root portion which is not symmetric about said first axis, and said adjusting step changes said first axis.

50. The method of Claim 41, wherein said crest of at least one tooth intersects said axis thereof.

51. The method of Claim 41, wherein said crest of at least one tooth does not intersect said axis thereof.

52. The method of Claim 41, wherein the angle of the axis varies for the teeth on a single row.

53. A method for designing a roller-cone earth-penetrating drill bit, comprising the actions of:

simulating the unconstrained motion of cones of a roller-cone earth-penetrating drill bit, including the three-dimensional trajectories of teeth thereof through rock being drilled;

and, for at least one of said teeth, adjusting the orientation of the crest of said tooth; and

adjusting the orientation of the top part of said tooth, in dependence on said trajectory.

54. The method of Claim 53, wherein said crest length is adjusted with respect to the scraping direction of said teeth through rock being drilled, and the top part is adjusted with respect to the indentation direction of said teeth through rock being drilled.

55. The method of Claim 53, wherein said crest length is adjusted to be perpendicular to the scraping direction of said teeth through rock being drilled, and the top part is adjusted to follow the indentation direction of said teeth through rock being drilled.

56. The method of Claim 53, wherein said bit comprises exactly three of said cones.

57. The method of Claim 53, wherein said teeth are inserts mounted on the bodies of said cones.

58. The method of Claim 53, wherein said teeth are formed integrally with the bodies of said cones.

59. The method of Claim 53, wherein said crests are straight.

60. The method of Claim 53, wherein said crests have a length which is between one-third and two-thirds of the width of a tooth.

61. The method of Claim 53, wherein said tooth is symmetric about an axis, and said adjusting step changes said axis.

62. The method of Claim 53, wherein said tooth has a tip portion which is symmetric about a first axis, and has a root portion which is not symmetric about said first axis, and said adjusting step changes said first axis.

63. The method of Claim 53, wherein said crest of at least one tooth intersects said axis thereof.

64. The method of Claim 53, wherein said crest of at least one tooth does not intersect said axis thereof.

65. The method of Claim 53, wherein the angle of the axis varies for the teeth on a single row.

66. A method for designing a roller-cone earth-penetrating drill bit, comprising the actions of:

simulating the unconstrained motion of cones of a roller-cone earth-penetrating drill bit, including the three-dimensional trajectories of teeth thereof through rock being drilled;

and, for at least one of said teeth, determining the indentation angle for said teeth, in dependence on said trajectory; and

orientating the top part of said tooth with respect to the indentation angle.

67. The method of Claim 66, wherein said bit comprises exactly three of said cones.

68. The method of Claim 66, wherein said teeth are inserts mounted on the bodies of said cones.

69. The method of Claim 66, wherein said teeth are formed integrally with the bodies of said cones.

70. The method of Claim 66, wherein said crests are straight.

71. The method of Claim 66, wherein said crests have a length which is between one-third and two-thirds of the width of a tooth.

72. The method of Claim 66, wherein said tooth is symmetric about an axis, and said adjusting step changes said axis.

73. The method of Claim 66, wherein said tooth has a tip portion which is symmetric about a first axis, and has a root portion which is not symmetric about said first axis, and said adjusting step changes said first axis.

74. The method of Claim 66, wherein said crest of at least one tooth intersects said axis thereof.

75. The method of Claim 66, wherein said crest of at least one tooth does not intersect said axis thereof.

76. The method of Claim 66, wherein the angle of the axis varies for the teeth on a single row.

77. A method for designing a roller-cone earth-penetrating drill bit, comprising the actions of:

simulating the unconstrained motion of cones of a roller-cone earth-penetrating drill bit, including the three-dimensional trajectories of teeth thereof through rock being drilled;

and, for at least one of said teeth, adjusting said teeth, in dependence on said trajectory; such that the normal of the surface of said teeth is in line with the penetration direction of said teeth through rock being drilled.

78. The method of Claim 77, wherein said bit comprises exactly three of said cones.

79. The method of Claim 77, wherein said teeth are inserts mounted on the bodies of said cones.

80. The method of Claim 77, wherein said teeth are formed integrally with the bodies of said cones.

81. The method of Claim 77, wherein said crests are straight.

82. The method of Claim 77, wherein said crests have a length which is between one-third and two-thirds of the width of a tooth.

83. The method of Claim 77, wherein said tooth is symmetric about an axis, and said adjusting step changes said axis.

84. The method of Claim 77, wherein said tooth has a tip portion which is symmetric about a first axis, and has a root portion which is not symmetric about said first axis, and said adjusting step changes said first axis.

85. The method of Claim 77, wherein said crest of at least one tooth intersects said axis thereof.

86. The method of Claim 77, wherein said crest of at least one tooth does not intersect said axis thereof.

87. The method of Claim 77, wherein the angle of the axis varies for the teeth on a single row.

88. A roller-cone earth-penetrating drill bit comprising:
one or more teeth, wherein the crest length is perpendicular to the scraping direction of said teeth through rock being drilled, and the top part follows the indentation direction of said teeth through rock being drilled.

89. The roller of Claim 88, wherein the angle of the axis varies for the teeth on a single row.

90. A roller-cone earth-penetrating drill bit comprising:
one or more teeth, wherein the normal of the surface of said teeth when said respective teeth first contacts cutting face is in line with the penetration direction of said teeth through rock being drilled.

91. The roller of Claim 90, wherein the angle of the axis varies for the teeth on a single row.

92. A roller-cone earth-penetrating drill bit comprising:
one or more teeth with an axis adjusted in accordance with the trajectory of said respective teeth onto a cutting surface.

93. The roller of Claim 92, wherein the angle of the axis varies for the teeth on a single row.

94. A roller-cone earth-penetrating drill bit comprising:
one or more teeth with an axis adjusted in accordance with an angle at which said respective teeth penetrates through a cutting surface into a volume of material therebeneath.

95. The roller of Claim 94, wherein the angle of the axis varies for the teeth on a single row.

96. A roller-cone earth-penetrating drill bit comprising:
one or more teeth with the crests and the top parts of said respective teeth adjusted in dependence on a three-dimensional trajectory of said respective teeth through formation being drilled.

97. The roller of Claim 96, wherein the angle of the axis varies for the teeth on a single row.

98. A roller cone bit designed by the method of Claim 1.

99. A roller cone bit designed by the method of Claim 17.

100. A roller cone bit designed by the method of Claim 29.

101. A roller cone bit designed by the method of Claim 41.

102. A roller cone bit designed by the method of Claim 53.

103. A roller cone bit designed by the method of Claim 66.

104. A roller cone bit designed by the method of Claim 77.